Executive Summary

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Introduction

Lawrence Livermore National Laboratory (LLNL), a U.S. Department of Energy (DOE) facility operated by the University of California (UC), serves as a national resource of scientific, technical, and engineering capabilities. The Laboratory's mission focuses on nuclear weapons and national security, and over the years has been broadened to include areas such as strategic defense, energy, the environment, biomedicine, technology transfer, the economy, and education. The Laboratory carries out this mission in compliance with local, state, and federal environmental regulatory requirements. It does so with the support of the Environmental Protection Department, which is responsible for environmental monitoring and analysis, hazardous waste management, environmental restoration, and assisting Laboratory organizations in ensuring compliance with environmental laws and regulations.

LLNL comprises two sites: the Livermore site and Site 300. The Livermore site occupies an area of 3.28 square kilometers on the eastern edge of Livermore, California. Site 300, LLNL's experimental testing site, is located 24 kilometers to the east in the Altamont Hills and occupies an area of 30.3 square kilometers. Meteorological and environmental monitoring activities are conducted at both sites as well as in surrounding areas.

This summary provides an overview of LLNL's environmental activities in 2000, including radiological and nonradiological surveillance, effluent and compliance monitoring, remediation, assessment of radiological releases and doses, and determination of the impact of LLNL operations on the environment and public health.

Environmental Monitoring Results

During 2000, the Environmental Protection Department sampled air, sewerable water, surface water, groundwater, soil and sediment, and vegetation and foodstuff. Samples were analyzed for radioactive and nonradioactive substances using (1) standard methods approved by the U.S. Environmental Protection Agency (EPA), (2) special systems such as the continuous monitoring system for Livermore site sewage, or (3) special analytical techniques designed to measure very low levels of radionuclides. Environmental radiation was also measured directly using dosimeters. More than 13,000 environmental samples were taken, and more than 260,000 analytical results were obtained.

Air Surveillance Monitoring

Ambient air was monitored for various airborne radionuclides (including particles and tritiated water vapor) and beryllium at the Livermore site, Site 300, and off-site locations throughout the Livermore Valley and Tracy areas. Concentrations of all monitored radionuclides and beryllium at all of these locations were well below levels that would endanger the environment or public health, according to current regulatory standards. For example, in 2000, the highest median plutonium concentration for samples collected at any air monitoring station was 0.025% of the federal Derived Concentration Guide (DCG). The DCG specifies the concentration of radionuclides in air or water that could be inhaled or ingested continuously 365 days a year without exceeding the DOE radiation protection standard for the public. Median concentrations of tritiated water vapor collected at Livermore Valley sampling locations showed a highest median value of 0.0004% of the DCG, while the highest median values on the Livermore site perimeter and within the site boundaries were, respectively, 0.002% and 0.09% of the DCG. The highest concentrations of beryllium on the Livermore site and Site 300 were 0.38% and 0.26%, respectively, of the guideline level established by the Bay Area Air Quality Management District and the EPA and are representative of naturally occurring levels.

Air Effluent Monitoring

In 2000, LLNL operated 76 samplers for measuring radioactivity in air effluent at six facilities at the Livermore site. These samplers extracted a measured volume of air from the exhaust stack of a facility or process and collected particles or vapor in a collection medium. Measured radiological air emissions from Livermore site operations remained well below levels of health and environmental concern. Building 331 emissions accounted for 23% of the estimated total tritium emissions from the site in 2000. The emissions in this facility during 2000 were lower than in 1999 and remained at a level far below those of the 1980s. Radiological emissions from the other monitored facilities were very low.

Nonradioactive air emissions from exempt and permitted sources at LLNL were quite small and typical of values in previous years. For example, total emission of nitrogen oxides from the Livermore site in 2000 was 54 kilograms per day, which is 0.07% of the quantity of this air pollutant released daily over the entire San Francisco Bay Area; corresponding numbers for reactive organics were 20 kilograms per day and 0.02%. The total emission of criteria air pollutants (nitrogen oxides, volatile organics, sulfur oxides, particulate matter, carbon monoxide, and lead) was 93 kilograms per day for the Livermore site and about 3.6 kilograms per day for Site 300.

Sewerable Water Monitoring

Discharges of radioactive and hazardous material to the combined sanitary and industrial sewer at the Livermore site are controlled by use of administrative and engineering controls, including limiting the disposal of those materials and routing some discharged material to retention tanks for later characterization and treatment. Flow-proportional and instantaneous samples of the site's wastewater are regularly collected and analyzed (for metals, radioactivity, toxic chemicals, and water-quality parameters) to ensure that LLNL's sewage effluent meets the requirements of the permit granted by the City of Livermore. In addition, the site effluent is monitored continuously for pH, regulated metals, and radioactivity. If concentrations are detected above warning levels, an alarm sounds and the effluent is automatically contained by LLNL's sewer diversion system. The diversion system captures all but the initial minutes of wastewater flow that causes a metal or radiation alarm, thereby protecting the Livermore Water Reclamation Plant (LWRP) and minimizing any required cleanup. Additional monitoring and diversion capability for pH allows the containment on site of even the initial minutes of a pH-related release.

In 2000, the Livermore site discharged an average of 0.97 million liters per day of wastewater to the City of Livermore sewer system, an amount that constituted 3.9% of the total flow to the system (about 16% of the Livermore site effluent was generated by Sandia National Laboratories/California). The Livermore site's sanitary sewer effluent was monitored continuously and sampled daily, weekly, and monthly to satisfy various permit compliance requirements.

LLNL achieved greater than 99% compliance with LWRP permit limits covering discharges into the sanitary sewer during 2000. However, three notices of violation (NOVs) were written for violations that occurred. One was for a silver exceedance, a second for a cyanide exceedance, and a third for excess chromium and nickel in categorical process wastewater. Two inadvertent discharges were detected by the continuous monitoring system in 2000, one involving a metal and the other a base; both of these instances warranted sewage diversion. During 2000, no sewer releases exceeded discharge limits for radioactive materials.

Surface Water Monitoring

Surface water sampling and analysis are a large part of the LLNL surveillance and compliance monitoring effort for the Livermore site, Site 300, and their surrounding areas. The waters monitored include storm water runoff, rainfall, water in the Livermore site Drainage Retention Basin, wastewater discharges from cooling towers and springs at Site 300, and a variety of other water that includes off-site reservoirs and ponds, drinking water taps both on and off site, and the Livermore site swimming pool.

Radioactivity detected in the storm water was all at small percentages of the levels allowed in drinking water (referred to as the maximum contaminant level, or MCL). The maximum tritium concentration in storm water effluent at the Livermore site was 3.7% of the MCL. Plutonium activities were not above the detection limit in the liquid phase of any storm water samples.

Livermore site storm water samples were also analyzed for chemical constituents. For those chemicals showing concentrations higher than our internal comparison criteria, most concentrations were lower at the effluent sample locations than the influent locations. Acute and chronic fish toxicity tests conducted on the storm water samples demonstrated no toxicity to the test species.

Results from monitoring in the Drainage Retention Basin provided additional evidence that water releases do not have a significant environmental impact.

At Site 300, tritium activities in storm water runoff samples were below the minimum detectable activity. Site 300 storm water contained levels of total suspended solids higher than our comparison criteria; however, as was the case for the Livermore site, these effluent levels were lower than the influent location.

Median tritium activities in rain samples in 2000 demonstrated a decrease compared to 1999 results. The median on-site measurement in rainfall during 2000 was 0.5% of the MCL. In drinking water sources, the maximum tritium activity was less than 0.3% of the MCL.

Overall, the results of surface water monitoring at both sites indicate compliance with established regulatory limits and negligible impact on the environment.

Groundwater Monitoring

Groundwater in the Livermore Valley and the Altamont Hills is monitored to assess the progress of remediation efforts in areas of known contamination, to measure the impact, if any, of LLNL operations on local groundwater resources, and to comply with numerous federal, state, and local permits. Groundwater samples are routinely measured for tritium, uranium, and other radioisotopes; gross radioactivity; toxic metals; a wide range of organic chemicals; and other general contaminant indicators. Special consideration is given to monitoring those dissolved elements and organic compounds that are known to be toxic in trace amounts.

The impact of Livermore site and Site 300 operations on off-site groundwater continued to be minimal in 2000. In the Livermore Valley, no monitored radioactive or inorganic nonradioactive constituent was found to exceed primary drinking water MCLs in any off-site well. In on-site wells, nitrates and chromium have been detected above their MCL, but these constituents have not been measured off site at levels above their MCL. The maximum tritium activity measured in the Livermore valley groundwater is less than 5% of the MCL.

At Site 300, tritium and depleted uranium have been released to groundwater from landfills and firing tables, but the boundaries of the slowly moving groundwater plumes lie entirely within site boundaries. The shallow groundwater plumes beneath Site 300 contain either volatile organic compounds (VOCs), tritium, nitrate, Freon, perchlorate, or depleted uranium, but they present no current health risks because this contaminated water is not used as a potable water supply for domestic, industrial, or agricultural use. LLNL is working with the regulatory agencies to contain and clean up groundwater contamination at both sites as necessary.

Soil and Sediment Monitoring

The impact of Laboratory operations on soil and sediment at the Livermore site in 2000 was insignificant and unchanged from previous years. The highest level of plutonium (isotopes 239 and 240) measured at the LWRP represented 1.3% of the National Council on Radiation Protection (NCRP) recommended screening limit for commercial or industrial sites. Other constituents of concern were measured at background or trace concentrations or were below the limit of detection. At Site 300, the concentrations of radionuclides and beryllium in

soil samples were generally representative of background or naturally occurring levels, as in previous years. Elevated concentrations of uranium-238 found in Site 300 soils in 2000 were attributed to contamination by debris from firing-table experiments.

Sampling and analysis of the vadose zone, carried out as part of the Livermore Groundwater Management Program, showed no evidence of contamination that will significantly affect groundwater.

Vegetation and Foodstuff Monitoring

LLNL impacts on vegetation and food in the Livermore Valley remained minimal in 2000. Tritium, which is the only measurable radionuclide in the vegetation and foodstuff monitoring program, was estimated to be well below levels of concern, even when organically bound tritium was taken into account. In 2000, tritium concentrations in wines from the Livermore Valley, California, and Europe are within the range of those reported in previous years and remain low in wines from all areas. Even the highest detected tritium value in Livermore Valley wine represented only 0.3% of the amount of tritium that EPA allows in drinking water (no health standards exist for radionuclides in wine).

Radiological Dose Assessment

Radiological dose assessment of air emissions was conducted for LLNL facilities having the potential to discharge radioactivity to the atmosphere. Air effluent emissions from about 170 points were evaluated and reported in 2000. These sources were of several types: stacks and other exhaust pathways from buildings, diffuse area sources generally external to buildings, and open-air firing tables at Site 300 where explosives experiments were conducted. The dose assessments were performed using conservative EPA-mandated computer models, actual LLNL meteorology, population distributions appropriate to the two sites, and 2000 radionuclide usage inventory and monitoring data.

LLNL reports public doses resulting from air releases of radionuclides during routine operations and from accidents. The principal exposure pathways taken into account are internal exposures from inhalation of air and ingestion of foodstuff and drinking water contaminated by the air releases. Releases of radioactivity from LLNL via water do not directly contribute to the public dose because this water is not used as a potable water supply for domestic, industrial, or agricultural use.

The most significant radiological effluent for the Livermore site from the standpoint of public dose continues to be tritium, the radioactive isotope of hydrogen. The calculated total potential dose for the sitewide maximally exposed individual (SW-MEI), (i.e., a hypothetical member of the public having the greatest possible exposure from Livermore site operations in 2000) from all Livermore site operations was 0.38 microsievert (0.038 millirem). The point source contributions to the dose include gaseous tritium modeled as tritiated water vapor as directed by EPA Region IX. Trends in this SW-MEI dose for the Livermore site over the last nine years show levels in the range 1.0 to 0.4 microsievert per year (0.1 to 0.04 millirem per year). These small radiation quantities exhibit large percentage but small absolute value fluctuations from year to year.

At Site 300, depleted uranium (containing isotopes with atomic weights 238, 235, and 234) remains by far the principal contributor to off-site dose. The calculated total potential dose to the SW-MEI during 2000 was 0.19 microsievert (0.019 millirem). This is well within the range of doses calculated over the past 10 years.

Conservatively calculated radiological doses to the maximally exposed public individuals from Livermore site and Site 300 emissions amounted to about 0.4% and 0.2%, respectively, of the EPA National Emission Standards for Hazardous Air Pollutants regulatory standard. These doses are a small fraction (about 1/8000) of the doses received by individuals from natural background radiation. Thus, the potential radiological doses from LLNL operations in 2000 were well within regulatory limits and were very small compared with doses from natural background radiation sources.

Environmental Compliance and Program Activities

LLNL works to ensure that its operations comply with all environmental laws and federal, state, and local regulatory guidelines. In addition to the extensive environmental monitoring, many compliance activities related to water, air, waste, waste reduction, community "right to know," and other environmental issues were addressed in 2000.

Groundwater Remediation

As a Superfund site, LLNL continued to treat groundwater at both the Livermore site and Site 300 under the jurisdiction of the Comprehensive Environmental Response, Compensation and Liability Act. LLNL's primary treatment method to remediate contaminated groundwater is pump-and-treat technology.

At the Livermore site, contaminants are removed at 11 treatment facilities, consisting of 9 groundwater and 2 soil vapor extraction facilities. Within each facility, wells are used to extract groundwater which is subsequently treated to remove volatile organic compounds (VOCs). A total of 80 groundwater extraction wells operated at an average flow of 3,640,000 liters per day and 2 vapor extraction wells operated at 841 cubic meters per day. Together the groundwater and vapor treatment facilities removed 269 kilograms of VOC mass in 2000. These efforts at control and remediation continue to reduce VOC concentrations throughout the site and reduce the plume sizes of contaminants.

In 2000, new treatment facilities were added to the Treatment Facility D (TFD), TFE, and TF518 areas at the Livermore site. Also, DOE/LLNL continued the evaluation of electroosmosis (EO) as a means to expedite the removal of VOCs from source areas characterized by high VOC concentrations in low permeability sediments. EO technology uses a grid of electrode-bearing wells to draw contaminated groundwater to the center wells. Based on studies conducted in 1999 at TF406, an EO system was installed at TFD in the summer of 2000. Preliminary data show the system to be effective at concentrating the contamination at the center wells.

Significant progress was also made at Site 300. Eight treatment facilities operated throughout 2000 and three new treatment facilities were added. Approximately 27.7 kilograms of VOCs were removed by treatment of 102,500,000 liters of groundwater and 352,905 cubic meters of soil vapor.

Waste Minimization and Pollution Prevention

LLNL continues to employ a weighted ranking system to prioritize and evaluate its waste streams. Cost, type of waste, and operational aspects are emphasized rather than simple considerations of total waste volume. Transuranic and transuranic-mixed and low-level wastes continue to be of highest priority for LLNL even though their relative quantities are low.

Comparing 2000 with the 1993 baseline, levels of waste in the four categories—radioactive, mixed, hazardous, and sanitary—have decreased by 78%, 59%, 66%, and 19% respectively. The total waste diverted from landfills in 2000 was more than 26,000 tons. Although LLNL has not yet achieved a 33% reduction goal for routine nonhazardous waste, its recycling percentage for nonhazardous waste was 85% in 2000.

The Laboratory has a Chemical Exchange Warehouse (CHEW) that enables employees to locate needed chemicals already on site. By reducing the need to buy new chemicals, production of waste is minimized. Employees can use ChemTrack, LLNL's computerized chemical inventory system, to search for chemicals in CHEW. In 2000, ChemTrack tracked some 167,000 chemicals through the use of bar codes, hand-held bar code laser scanners, and customized software.

Air, Wastewater, and Water Compliance

LLNL continued to perform all activities necessary to comply with clean air and clean water requirements. In 2000, the Bay Area Air Quality Management District issued or renewed 129 operating permits for the Livermore site. The San Joaquin Valley Unified Air Pollution Control District issued or renewed permits for 42 air emissions sources at Site 300. LLNL has permits for underground and aboveground storage tanks and for discharge of treated groundwater, industrial and sanitary sewage, and storm water. Site 300 has additional permits for inactive landfills, cooling tower discharges, operation of the sewer lagoon, septic tanks, and leach fields. The Laboratory complies with all requirements for self-monitoring and inspections associated with these permits.

Endangered Species

LLNL meets the requirements of both the U.S. Endangered Species Act and the California Endangered Species Act as they pertain to endangered or threatened species and other species of special concern that may exist or are known to exist at the LLNL sites. In 2000, biological assessment surveys were performed for special-status species at 82 LLNL project construction (ground-disturbing) areas. Although no active San Joaquin kit fox dens were discovered, 3 occupied American badger dens were found. In addition, 11 active burrowing owl dens were discovered at Site 300; the owls were marked with leg bands to perform long-term studies, monitoring, and conservation of the species. A population of the California tiger salamander (*Ambystoma californiense*), a federal species of concern, was monitored at Site 300. And, at both the Livermore site population and Site 300 the federally threatened California red-legged frog (*Rana aurora draytonii*) was monitored and protected. In 2000, the Central Drainage Retention Basin (DRB) was drained in an effort to eradicate non-native bullfrogs (*Rana catesbeiana*), which are a predator of the California red-legged frog.

Four rare plant populations were monitored at Site 300 in 2000: the large-flowered fiddleneck (*Amsinckia grandiflora*), a federally listed endangered plant species; the big tarplant (*Blepharazonia plumosa*), a California Native Plant Society "rare" plant; the diamond-petaled poppy (*Eschscholzia rhombipetala*); the big tarplant (*Blepharazonia plumosa*), a California Native Plant Society "rare" plant; and gypsum-loving larkspur (*Delphinium gypsophilum* ssp *gypsophilum*) listed on the California Native Plant Society Rare Plant 4 list. In April 2000, an area at Site 300, the *Amsinckia grandiflora* Reserve, was designated a critical habitat area (CHA) by declaration of the Secretary of the U.S. Department of Energy. LLNL has also

established an experimental population within the reserve and will continue working with the U.S. Fish and Wildlife Service on the continued monitoring of the native and experimental fiddleneck populations. The number and size of the big tarplant populations increased from 2000 abundances. The number of diamond-petaled poppy plants were also observed in 2000.

Environmental Occurrences

Notification of environmental occurrences at the Laboratory is required by a number of environmental laws, regulations, and DOE orders. LLNL responded to nine incidents that required federal and/or state agency notification during 2000. None of these caused adverse impact to human health or the environment.

Contract Performance Measures

University of California's Prime Contract W-7405-ENG-48 includes four performance measures related to environmental protection activities: (1) radiation dose to the public, (2) process and solid waste generation, (3) environmental violations, and (4) environmental releases. At the end of 2000, DOE assigned LLNL a score of excellent as an average for these environmental performance measures.

Integrated Safety Management and Work Smart Standards

LLNL has implemented an Integrated Safety Management System (ISMS) in accordance with the requirements of the University of California's Prime Contract. ISMS is designed to ensure the systematic integration of Environment, Safety, and Health considerations into management and work practices so that missions are accomplished while protecting the public, workers, and the environment. The Work Smart Standard (WSS) process is an integral part of ISMS whereby safety and environmental professionals identify ES&H hazards and establish standards of operation appropriate to the particular work being performed. The final WSS set of standards was approved in 1999 and is included in the Prime Contract. The WSS set includes more than 250 requirements directly related to the environment.

Conclusion

The current techniques LLNL uses for environmental monitoring are very sensitive, allowing detection of extremely low levels of constituents. The combination of surveillance and effluent monitoring, source characterization, and dose assessment shows that radiological doses to the public caused by LLNL operations are less than 1% of regulatory standards and are about 8000 times smaller than the doses received from natural background radiation. The analytical results and evaluations generally show continuing low contaminant levels, reflecting the responsiveness of the Laboratory in controlling pollutants.

In 2000, LLNL successfully engaged in environmental compliance activities related to water, air, waste, waste reduction, and other environmental issues. Some key examples include groundwater remediation activities, waste minimization efforts, and recycling efforts that diminished the quantity of waste sent to landfills. Actions to protect endangered species at both LLNL sites also continued.

In summary, the results of the 2000 environmental programs demonstrate that LLNL is committed to protecting the environment and ensuring that its operations are conducted in accordance with applicable federal, state, and local laws and regulations. The environmental impacts of LLNL operations are minimal and pose no threat to the public or the environment.